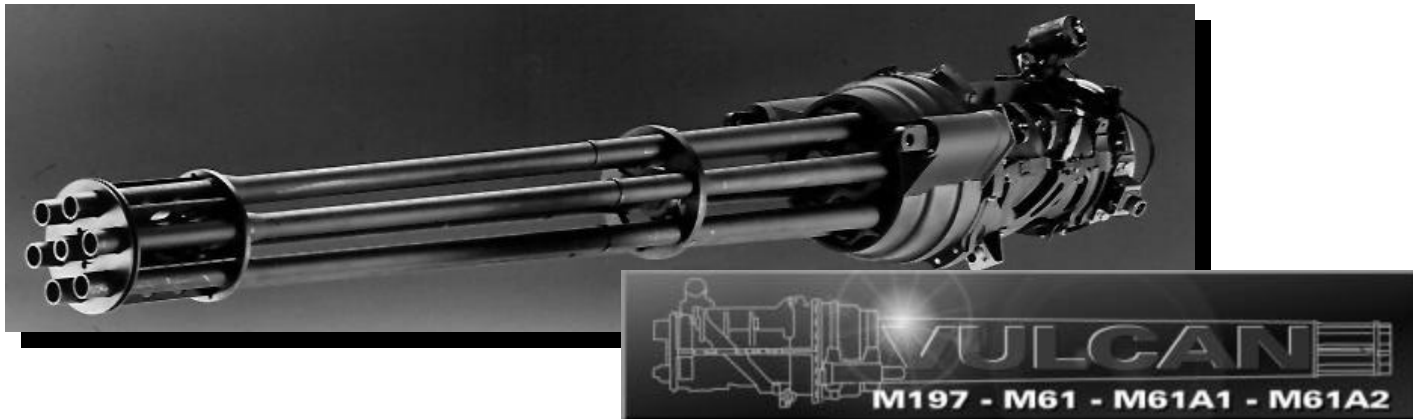


GENERAL DYNAMICS
Armament Systems

Derivation of a Pressure Limit for the M61 Family of Guns



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36th Gun & Ammunition Symposium & Exhibition
San Diego, California

##

The M61 Family of Guns



M197



M61A1



M61A2

The M61 History Project Vulcan: 1949 - 1959



Section 2-2 Design Considerations

This section describes
designing the weapon
categorized as follows:

Reliability
Compatibility
Performance
Ease of Maintenance

Reliability has been

Reliability has been
of Project Vulcan.
been concerned with
the gun, eliminating
fire, and deterioration
Examples of design changes
led to high reliability
of this report. The
which describes the
Many of the design changes
made to eliminate problems

Bolt Assy
Pin, spring
Block, lock
Shaft, bolt
Stop, cone
Pin, cone
Pin, firing
Barrels
Muzzle Clamp
Center Barrel
Firing Contact
Contact case

Section 3-1. Bolt Assembly

The bolt assembly is the
the only one of each the
bolt is also the only firing
the transportation of the
The T171E3 bolt, without
patent from the Model C
put forth and much more
history design was known.

The following paragraph
the assembly from the first
used in the T171E3. Material
parts were changed and
changes are indicated below:

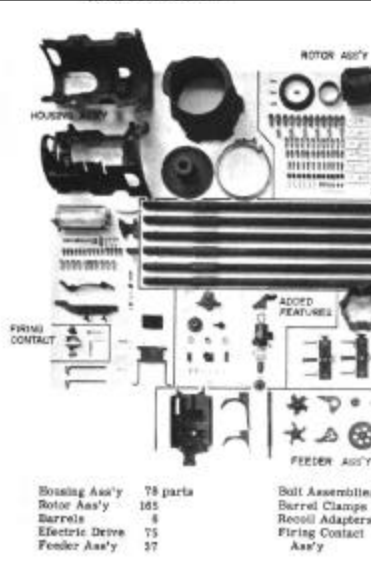
1. Automating the locking
locking loaded shaft
"Muzzle-lock" design
Two coil springs
2. Attaching the muzzle
stop ring
Two-piece shaft (first
by one, 60° apart)
3. Attaching lock block to
change and groove in
Block pin



Figure 3-1. Prototype Bolt Design

Section 3-3. Rotor Assembly

T171E3 ROTOR DESIGNS



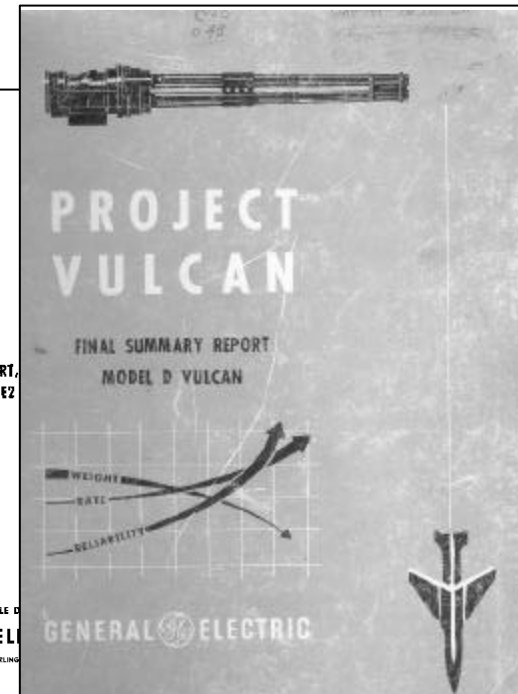
Bossing Assy	78 parts	Bolt Assemblies
Rotor Assy	165	Barrel Clamps
Barrels	8	Recoil Adapters
Electric Drive	75	Firing Contact
Fender Assy	37	Ass'y

PROJECT VULCAN

FINAL SUMMARY REPORT,
M61(T171E3) AND T171E2

DEPARTMENT OF ARMY
ORDNANCE CORPS
BOSTON ORDNANCE DISTRICT
DEPARTMENT OF ARMY PROJECT NUMBER
503-28-028

MISSILE AND SPACE VEHICLE
GENERAL ELECTRIC
MISSILE PRODUCTION SECTION, BURLING



The Pressure Definition Problem



- The M61 was designed before sophisticated analytical techniques were common.
- Ammunition pressure measurement technology from the 1930s & 40s did not provide an accurate peak chamber pressure for minor caliber gun design.

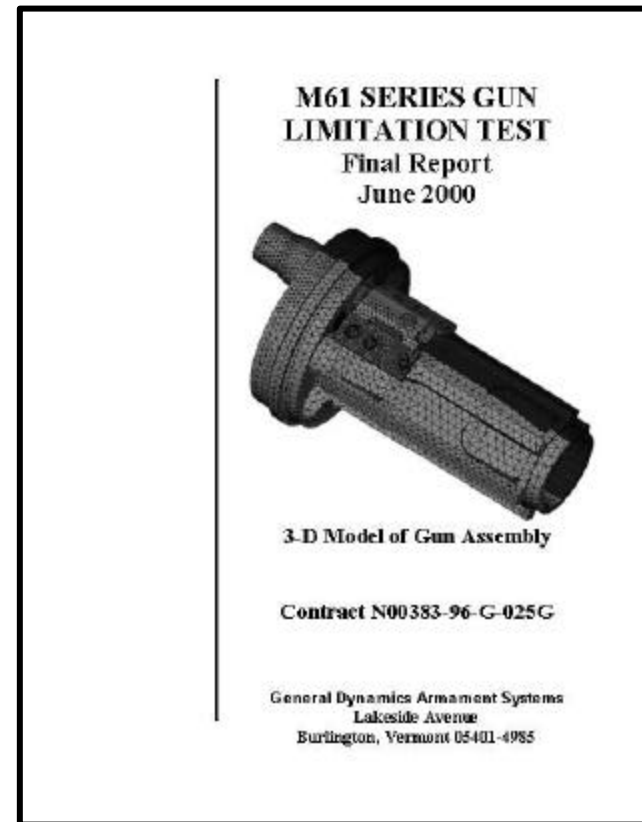


The 'Model C' Gatling Gun
Predecessor to the M61

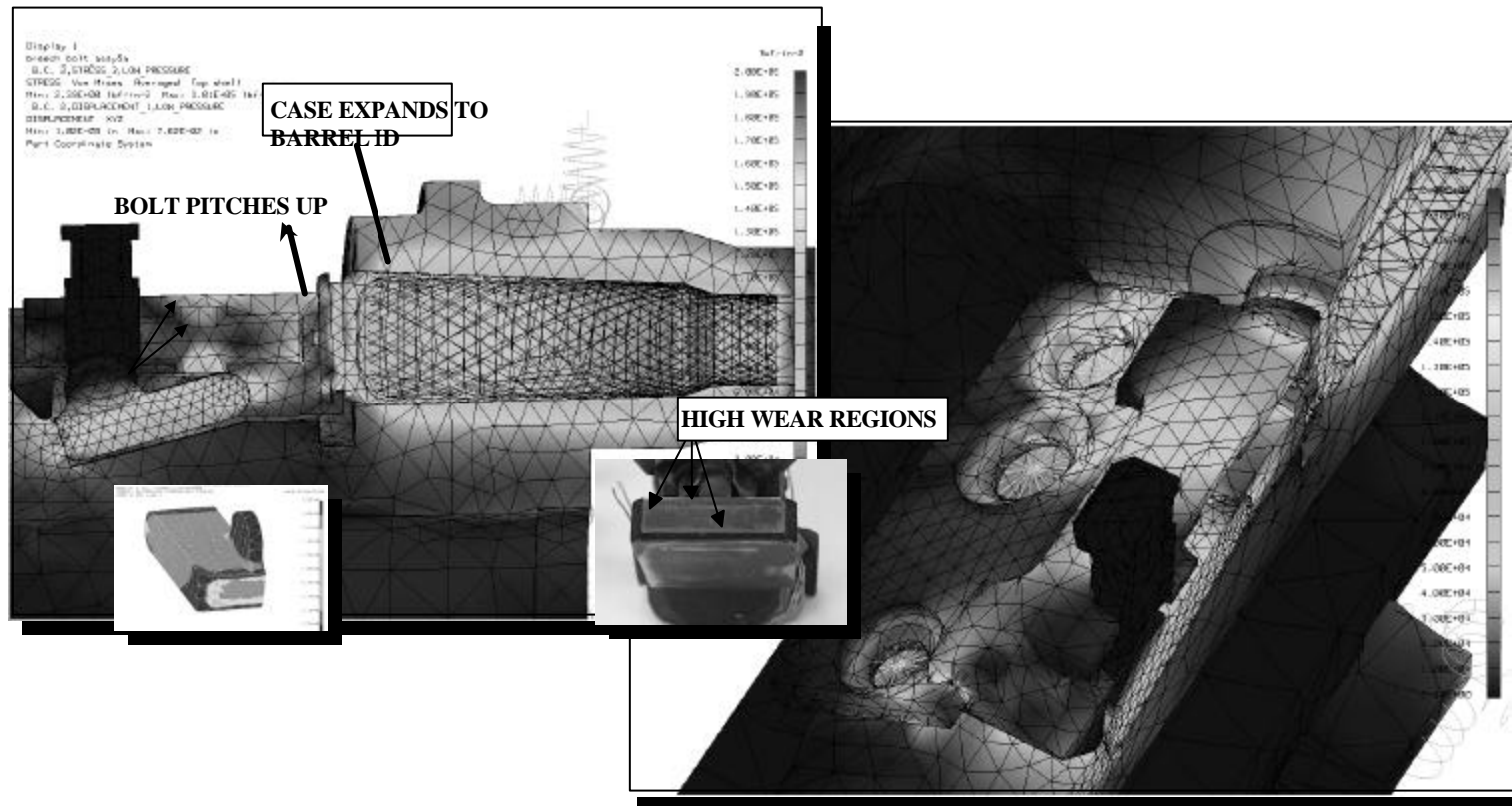
The M61 Reverse Engineering Program



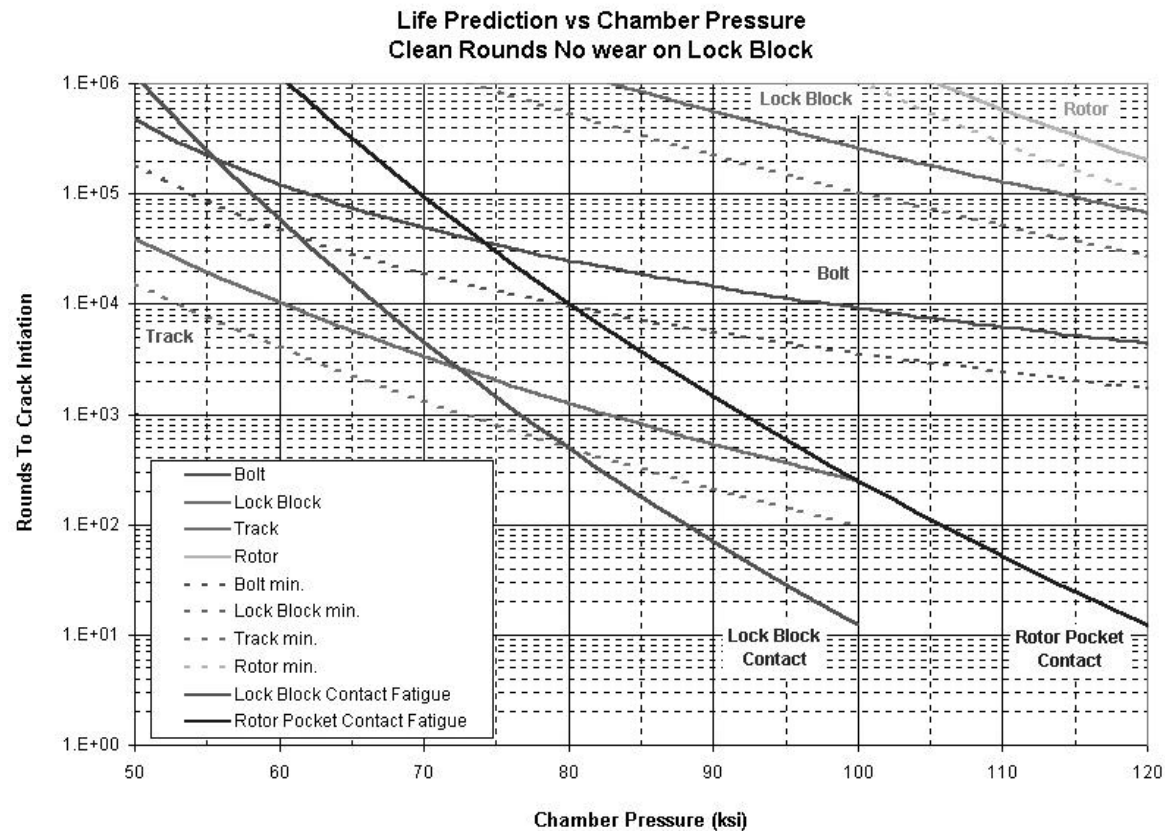
- Detailed experimental and analytical look at the M61.
- USAF-funded through a USN contract vehicle.
- First comprehensive look at the M61 in 30 years.



M61 Vulcan Firing Loads



M61 Parts Life vs. Peak Chamber Pressure Relationships



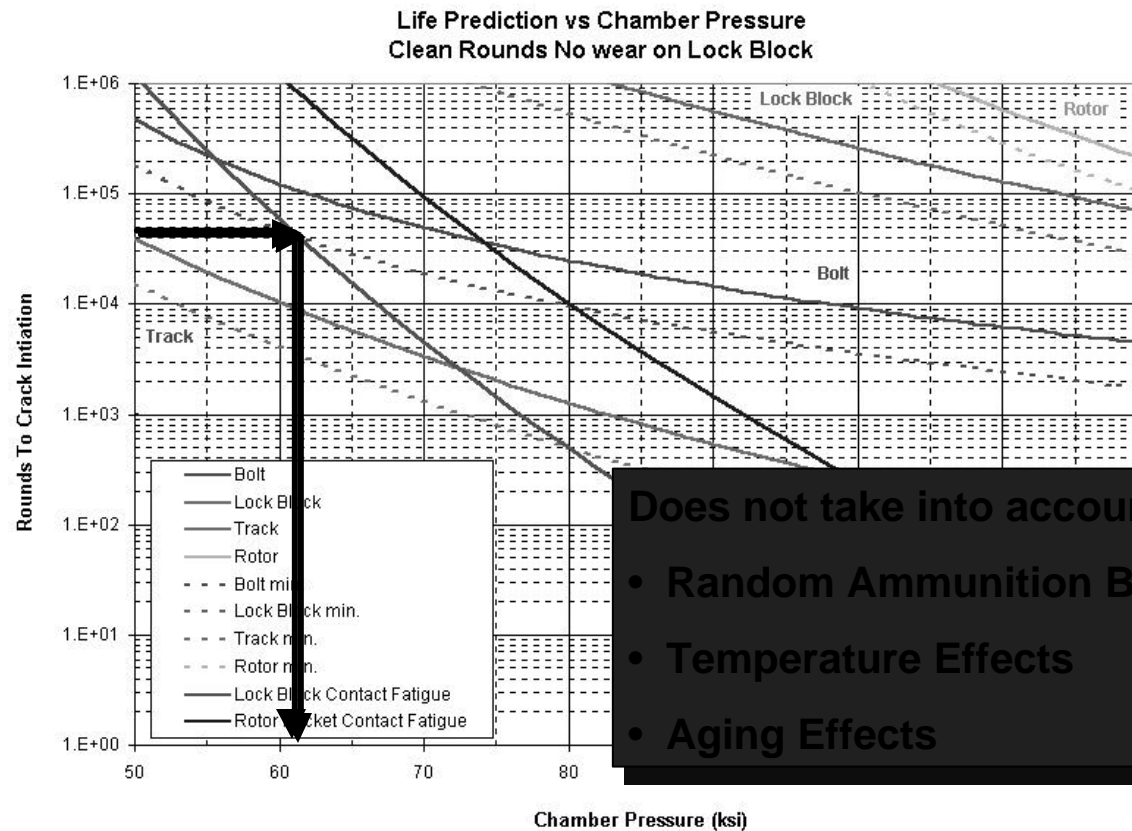
The Next Step



- **With the results of the M61 Reverse Engineering Study, we can finally generate a methodology to answer the question:**

What Peak Pressure Can the M61 Tolerate ?

The Incorrect Way...



Does not take into account:

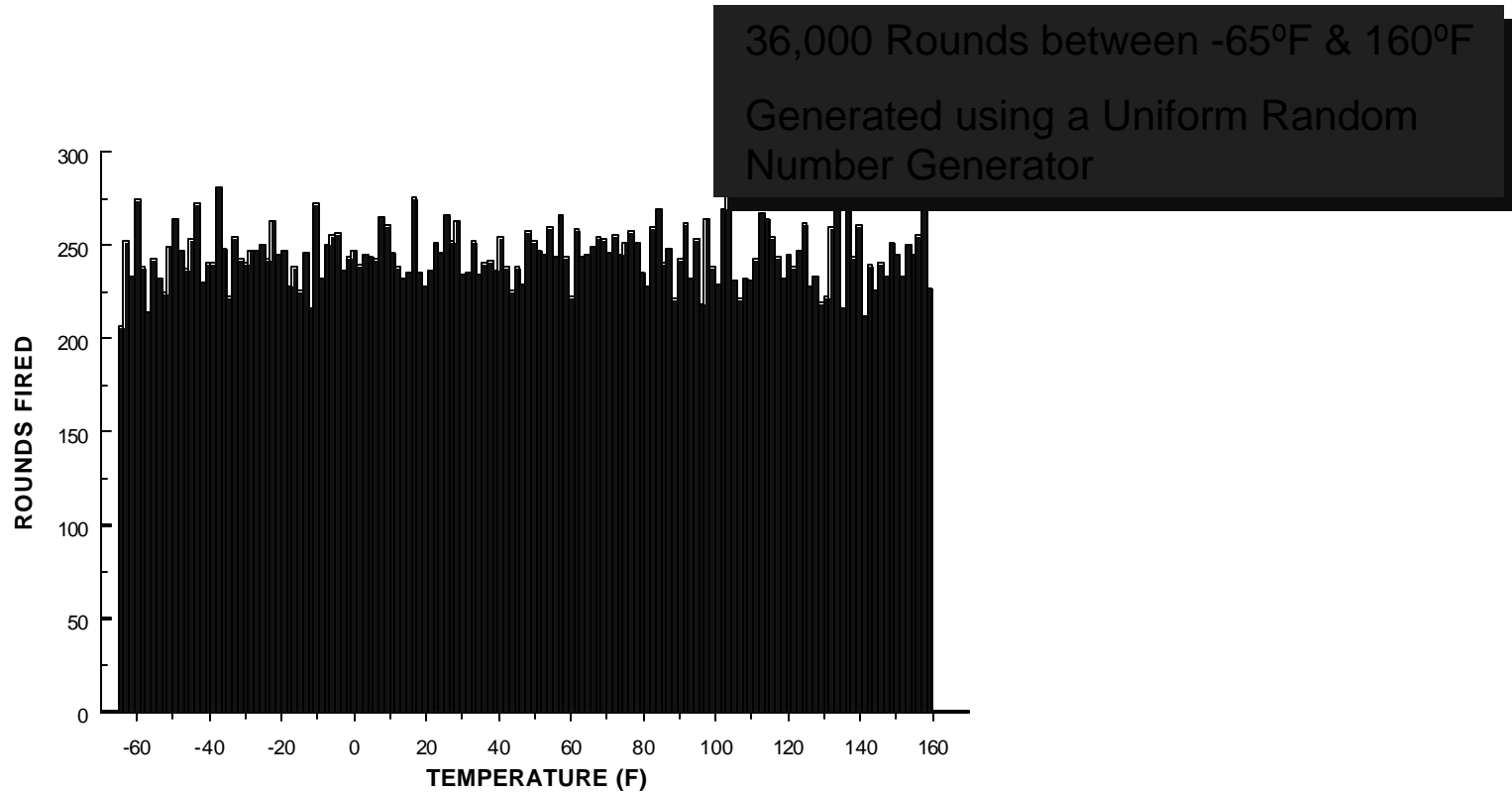
- Random Ammunition Behavior
- Temperature Effects
- Aging Effects

The Correct Way

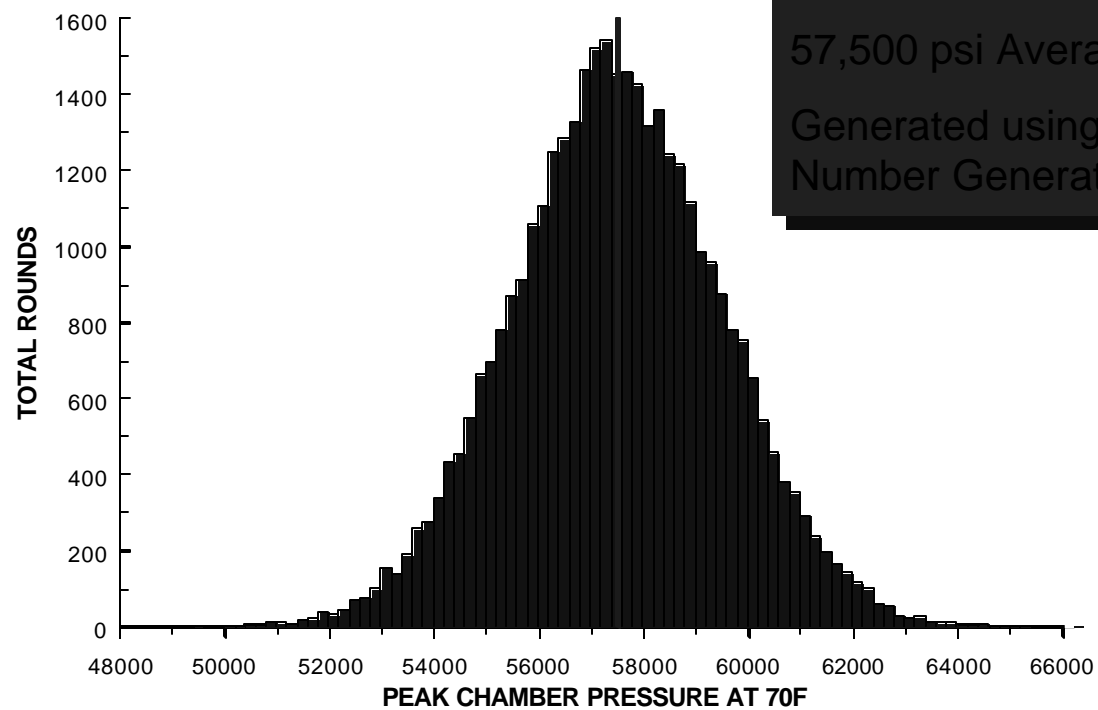


- **Assume a known distribution of pressures & temperatures are fired.**
- **Assess the damage caused by each round.**
- **Estimate the number of rounds to failure.**

Step 1: Assume a Temperature Distribution



Step 2: Assume a Pressure Distribution

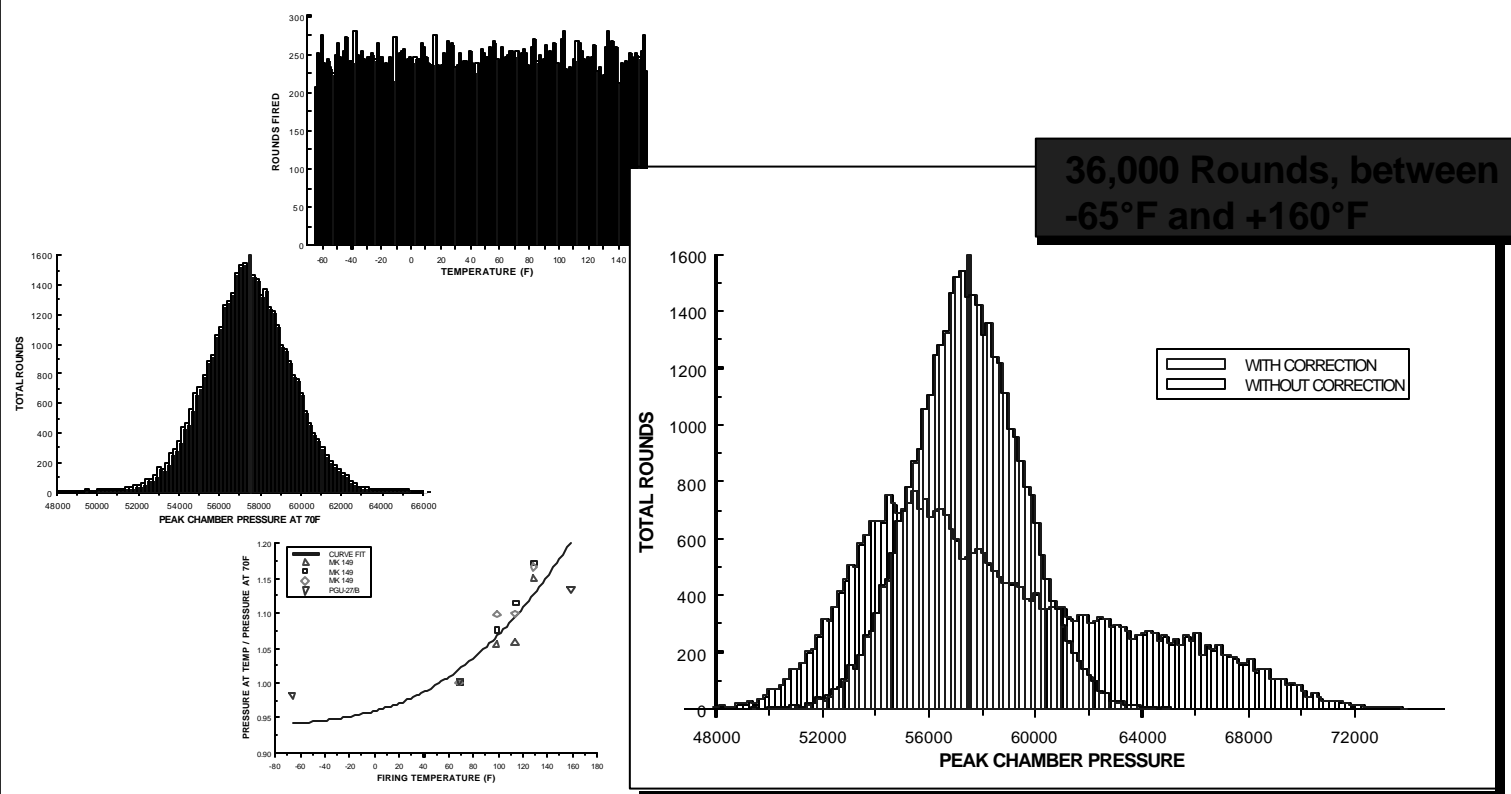


36,000 Rounds

57,500 psi Average / 2,000 psi s

Generated using a Gaussian Random Number Generator

Step 3: Correct the Pressures for Temperature Effects

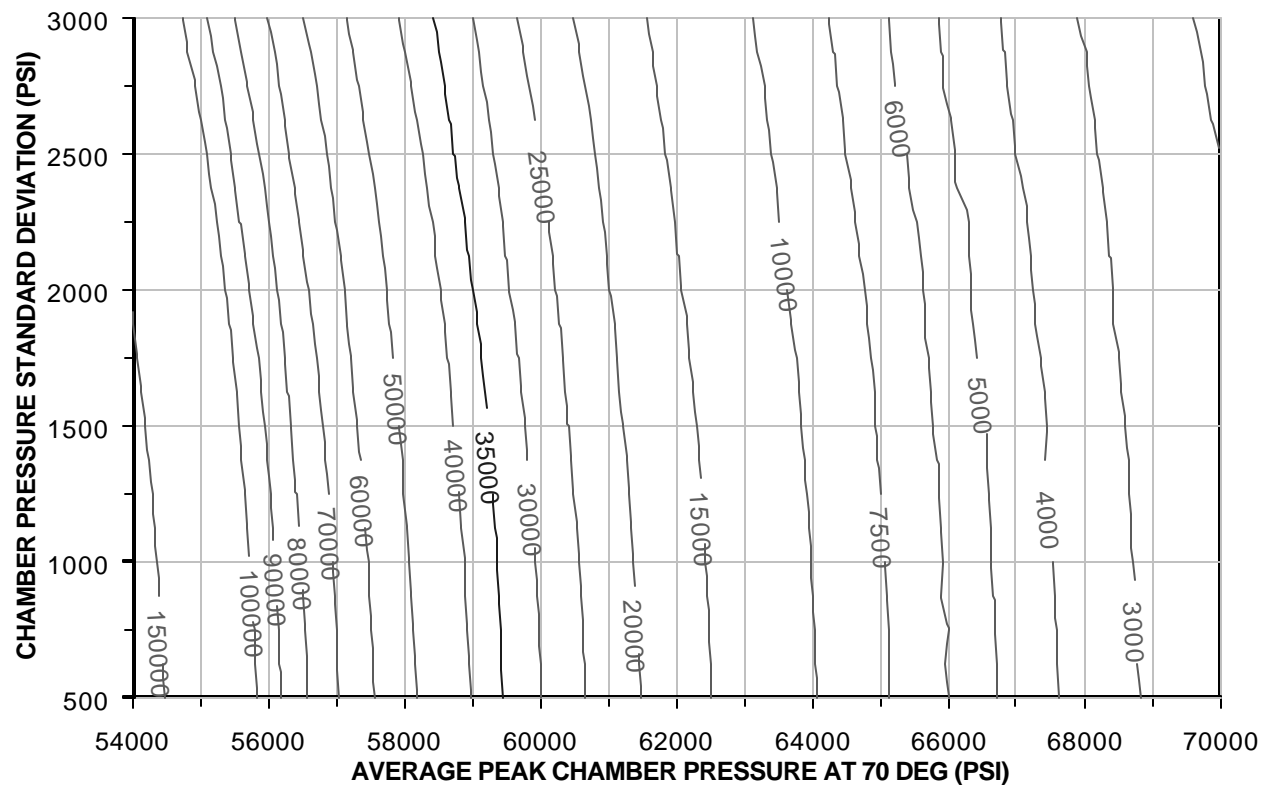


Step 4: Assess the Gun Damage

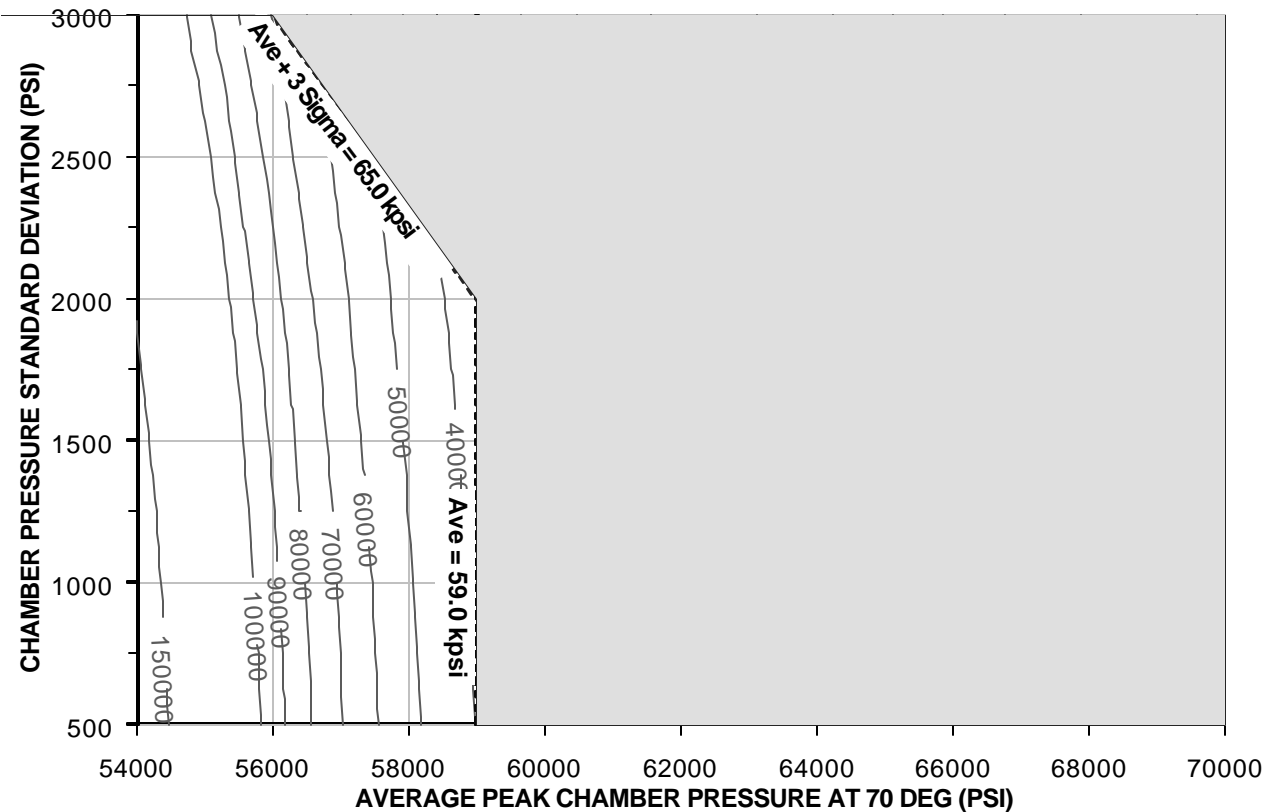


- **Mean pressure varied from 54,000 to 70,000 psi at 70°F**
- **Standard Deviation varied from 500 to 3,000 psi.**
- **Even temperature distribution from -65 to +160°F.**
- **Miner's Rule applied until failure is predicted.**

Step 5: Map the Predicted MRBF Results For No Maintenance



Step 6: Set the Limits to Maintain a Desired Maintenance Interval



Summary Points



- **Ammunition pressure limits are gun constraints and belong to the weapon.**
- **Analysis can be used as a basis to estimate the structural response of the weapon to varying ammunition behavior.**
- **Realistic ammunition pressure limits can be derived that take into account:**
 - **Random ammunition effects**
 - **Temperature effects**
 - **Effects of aging**